Basics of Meteorology and Conventional Metrological Instruments in Hydrometric Context

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WHY STUDY METEOROLOGY?

- Warning of Severe Weather
- Real-time preparation of weather analyses
  - Study of climate,
  - Local weather-dependent operations (for example, local aerodrome flying operations, construction work on land and at sea),
- Research in meteorology and climatology
- Agriculture
  - Timing of Planting, Harvesting, etc to Avoid Bad Weather, Hazards to Livestock
- Transport & Services
  - Shipping, Aviation, Road Gritting, Flood Warnings,…
- Commerce
  - Should a Supermarket Order BBQs and Ice-Cream, or Umbrellas?

Figure 1 Gujrat Flood Aug 2019

Figure 2 Droughts in India 2019

Figure3 -Pune Urban Flood 23r[d] Sep 2019

Figure4: Cyclone fani Odisha May 2019

WHAT DO WE WANT TO KNOW?

- Temperature
- Wind Speed
- Wind Direction
- Clouds
  - Type, Extent, Altitude
- Precipitation?
  - Type, Amount, Location
- Visibility
  - Fog, Haze
- Humidity
- Trends in all of these
- Timing of Significant Changes
- Occurrence of Extreme Events

PHYSICAL PROCESSES & UNDERSTANDING

Physical Processes:

- **Thermal** – Atmospheric Dynamics are Ultimately Driven by Temperature Gradients Arising from Uneven Solar Heating
- **Pressure Gradient Forces** – Immediate Cause of Horizontal Motions
- **Moisture** – Effect of Water Vapour Content on Air Density, and Release of Latent Heat has a Major Impact on Convection

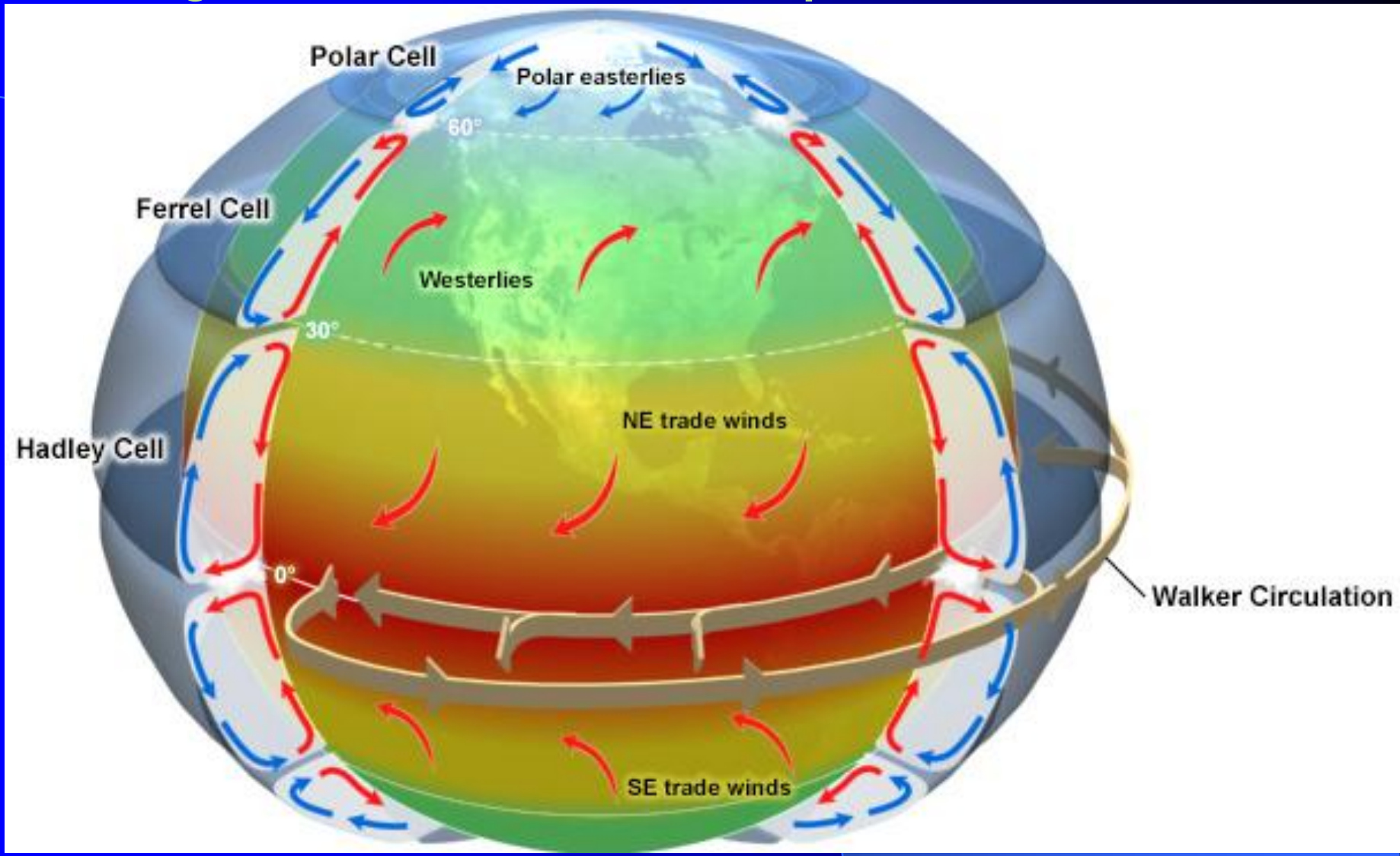
Physical Understanding:

- An Extensive Set of Measurements over a Wide Area, Coupled with an Understanding of the Physical Processes Allows general Conditions to be Assessed and Forecasts to be Made for a Wide Area a Day or Two Ahead.

ATMOSPHERICS OF METEOROLOGY

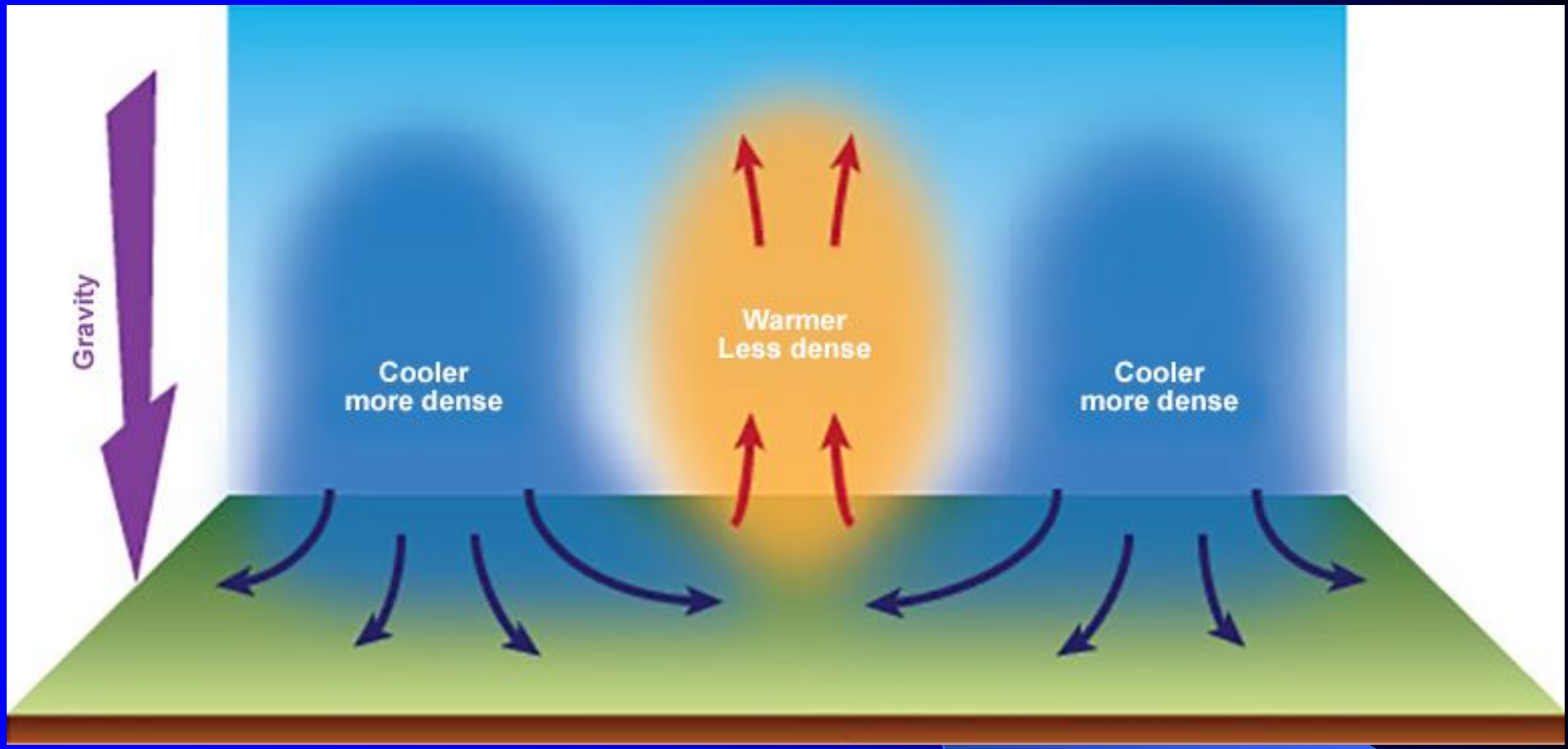
GLOBAL CIRCULATIONS

Prevailing Global Winds: Basic Set-up

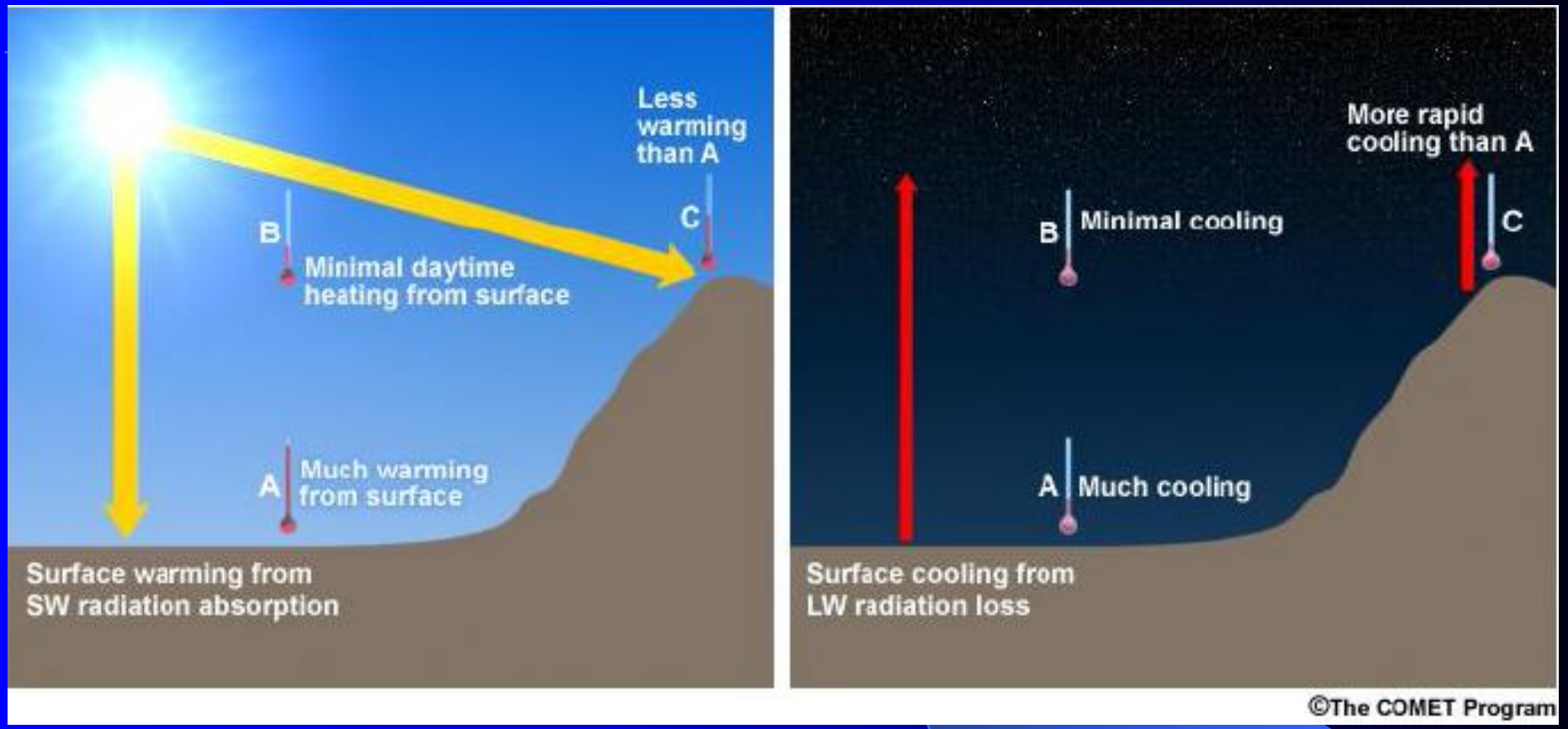


DRIVERS OF WEATHER

Atmospheric Vertical Motions



EFFECT OF ALTITUDE ON TEMPERATURE (DAY/ NIGHT)



WHAT CAUSES SEASONS

Seasons are Caused by Tilt of Earth. as Results Sun will Not be Focused Always Over Equator. Area where Sun Rays are at 90^{o} Angle to Earth Heats up

Northern Hemisphere

- ✓ Summer:- Near Pole: June-August, Near Equator: March-May

Southern Hemisphere

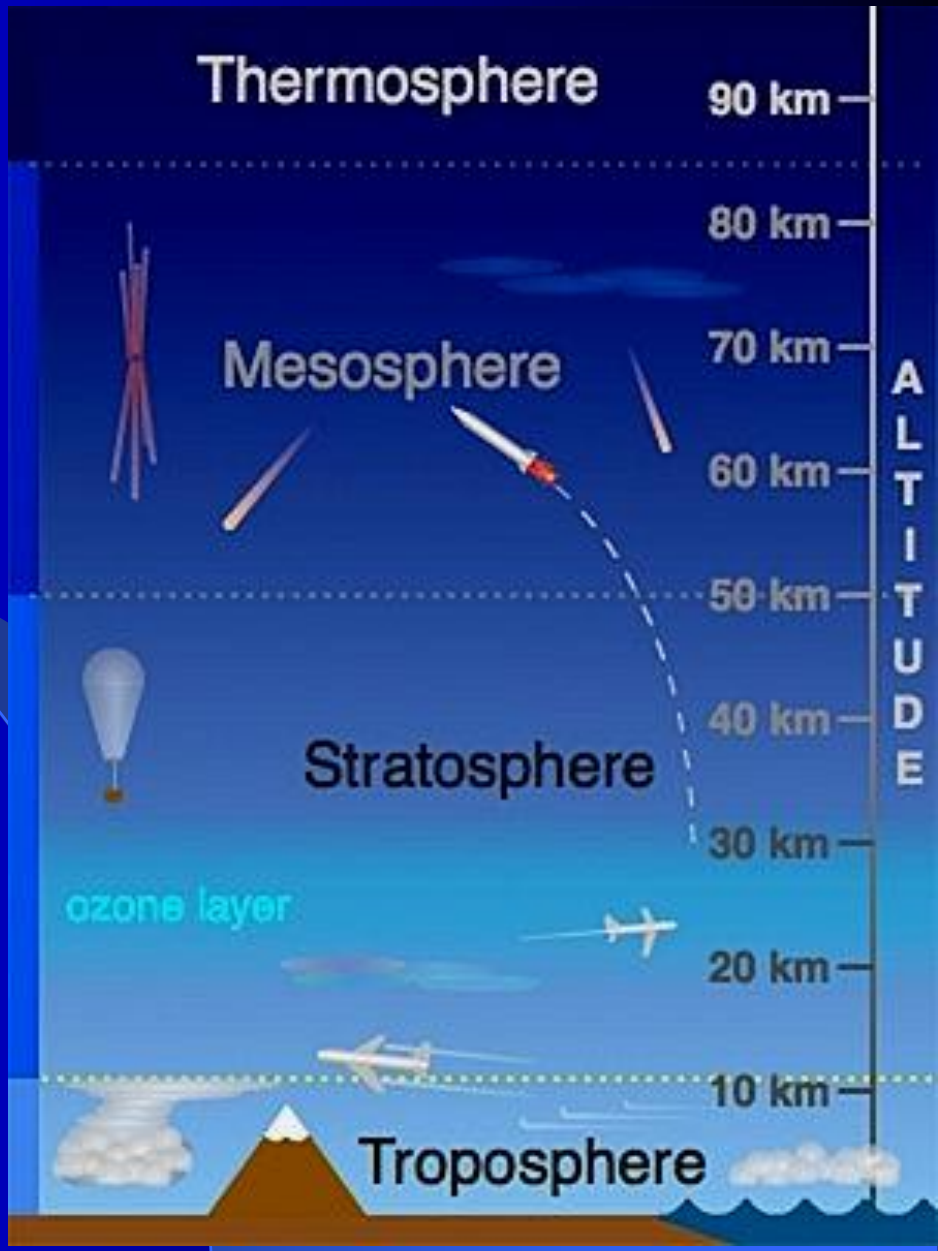
- ✓ Summer:- Near Pole: January-March

- ❖ 3 Cell Circulation Theory (Polar, Ferrel and Hadley) is Weakened Due to Less of Temperature Difference between Equator and Poles.
- ❖ In Winter Hemisphere, 3 Cell Circulation is Strengthened due to Strong Temperature Difference between Equator and Poles. This Results in Stronger Winds and Storm Systems in Winter.
- ❖ Seasons are not Caused by Earth being Further Away from Sun during Portions of its Revolution Around it. If this were Cause, Entire Earth Would have Same Seasons, which is Not Case

ATMOSPHERIC LAYERS AND AIR MIXTURES

Earth's Atmosphere is a Mixture of Gases Surrounding Planet. Besides Providing Oxygen to Breathe, it Helps make Life on Earth Possible in Many Ways.

- Shields Planet Earth from Harmful UV Radiation Coming from Sun
- Warms Surface of Earth by about 33° C (59° F) via Greenhouse Effect
- Largely Prevents Extreme Differences between Daytime and Night Time Temperatures.
- Contains 78% Nitrogen, 21% Oxygen, Argon, Carbon Dioxide and many other Gases Present makes up < 1% of Atmosphere's Mixture of Gases.
- Amount of Water Vapor Present Varies a lot, but on Average it is 1%.
- Earth's Atmosphere has 4 Layers



CLOUDS AND PRECIPITATION

Clouds are Made up of Tiny Water Droplets and Ice Crystals that are Small and Float in Air. If Droplets become Large Enough, it will be Visible as Cloud or Fog. If they become further Larger, they Fall as Rain (or Snow).

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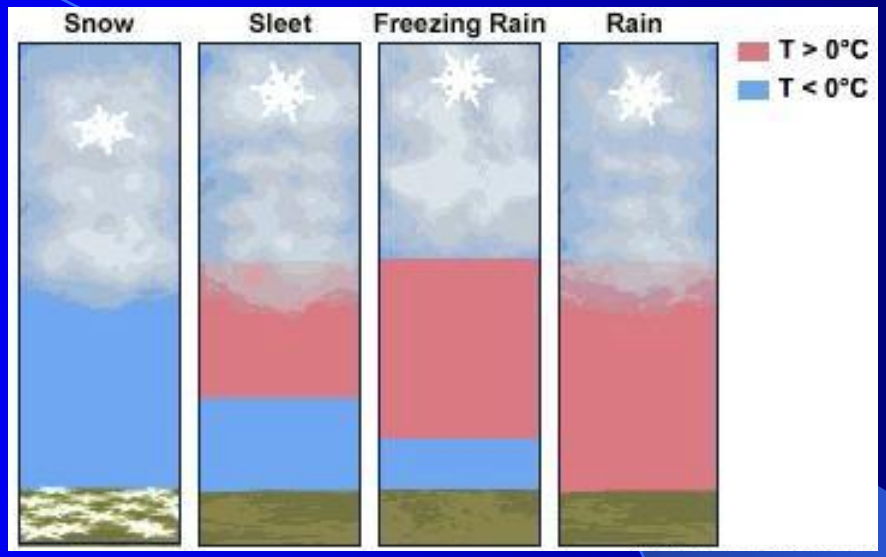
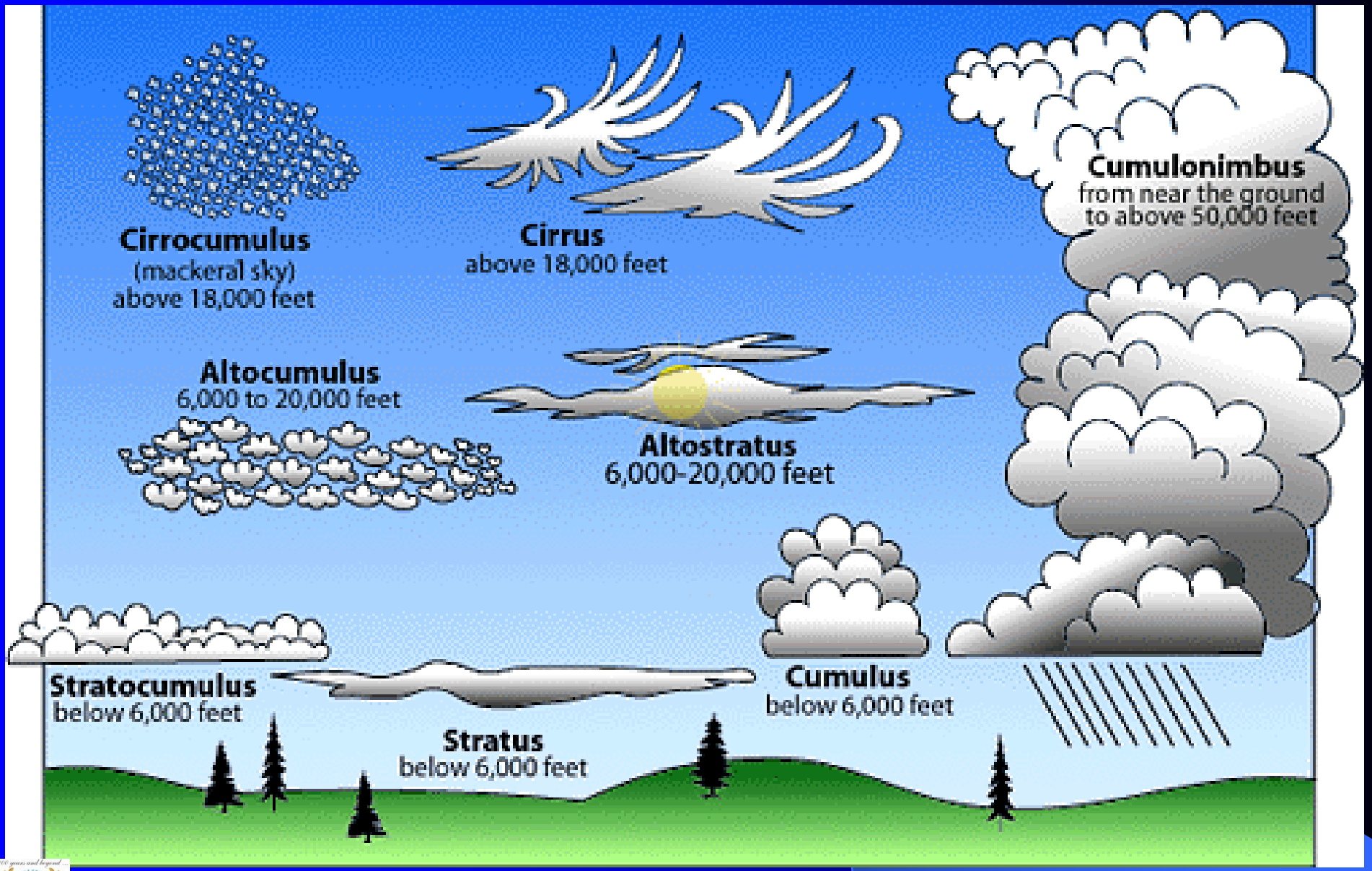


Precipitation types and governing temperatures

COMMON TYPES OF CLOUD IN TROPOSPHERE



Basics of Meteorology

METEOROLOGY, WEATHER AND CLIMATE

Meteorology

Study of *Phenomena of Atmosphere* – Includes Dynamics, Physics, And Chemistry of the Atmosphere.

- More Commonly thought of as Restricted to the Dynamics and Thermodynamics of Atmosphere as it Affects Human Life.

Weather

State of the Atmosphere; Mainly with Respect to its Effects upon Human Activities. Short term Variability of Atmosphere (Time Scales of Minutes to Months).
Popularly thought of in terms of: *Temperature, Wind, Humidity, Precipitation, Cloudiness, Brightness, and Visibility.*

- A Category of Individual/Combined Atmospheric Phenomena which describe the Conditions at Time of an Observation.

Climate

Long Term Statistical Description *of* Atmospheric Conditions, Averaged Over a Specified Period of Time - Usually Decades.

BASICS

What is Weather Station?

Device that Collects Data Related to **Weather** and Environment using Many Different Sensors. **Weather stations** Sensors may Include Thermometer for Temperature Readings, Barometer for Atmospheric Pressure, as well as Other Sensors to Measure Rain, Wind, Humidity, Radiation and More.

What is a Meteorological Instrument?

Equipment used to Sample State of Atmosphere at a given Time and Space. Meteorological Measurements does not Use much Lab Equipment but Relies more on Field-Mode in situ Observation and Remote Sensing Equipment.

What is Meteorological Data?

Set of Surface Measurements Important To Meteorologists. They give a Snapshot of Weather Conditions at One Single Location and are usually at a Weather Station, a Ship or a Weather Buoy. Measurements taken at a Weather Station can Include any Number of Atmospheric Observables.

SYNOPTIC METEOROLOGY

- Observations of Atmospheric Properties are taken at Different Locations at the same Time to Construct Weather Maps for Analysis.
- Meteorologists Call these Measurements ***Synoptic*** and Studies Using these Measurement ***Synoptic Meteorology.***

HOW FAR AHEAD IN FORECASTING ?

- **Ideally:**
  - As Far Ahead As Possible!
- **In Practice**
  - 3-5 days is Limit of Reasonable Quantitative Forecasts.
  - Medium-Range Forecasts (5-10) days are Made, but Limited to Large-Scale Pressure Field and winds, **NOT** Detailed Conditions.

CONVENTIONAL INSTRUMENTS

Metrological data were collected with manual interventions

WHY TO STUDY WEATHER

We study weather because we want to know how it will impact our daily lives, and it is through our senses that we interact with the world around us.

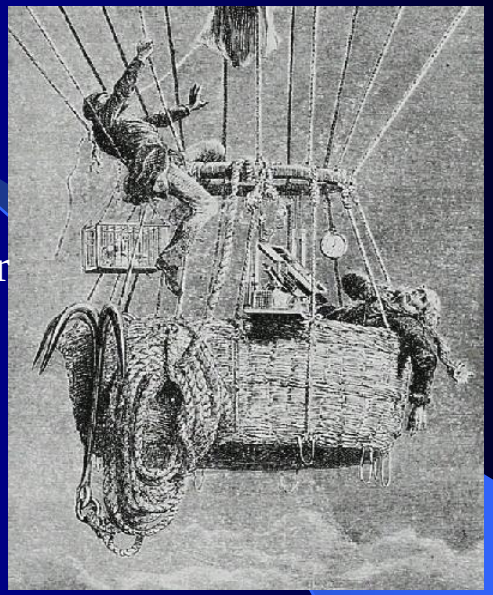
The principle parameters in relation to "weather" and "climate"

(i) Air temperature
(ii) Air pressure
(iii) Humidity
(iv) Clouds - existence of, types
(v) Precipitation (rain, snow hail etc.)
(vi) Visibility
(vii) Wind
(viii) Solar radiation

BRIEF HISTORY OF EARLY CONVENTIONAL INSTRUMENTS

- Scientific perspective did not really begun until 1800's
- These instruments were quite simple and more aesthetic e.g. weather vanes often with metal replica of rooster were used for little more than determining the general wind direction, means whether it was blowing from say the north or the north-west.
- In 1800 scientist began taking more detailed measurements.
- James Glashier (1809-1903) first person to fly a balloon to a altitude of 9000-11,200 meter and measured the pressure at this height as one third of the ground level pressure.

Hygrometer

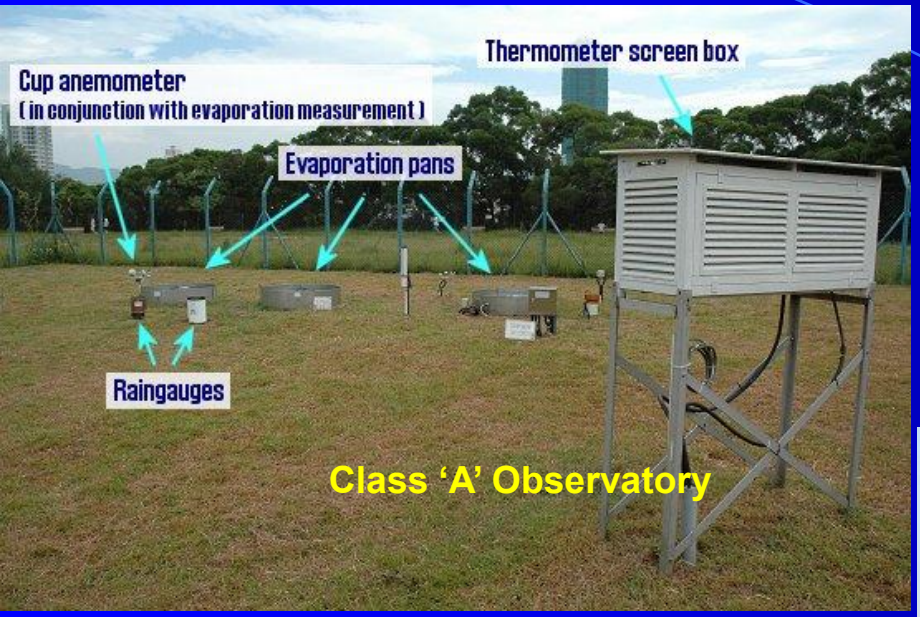


METEOROLOGICAL INSTRUMENTS

Instruments Housed in Full Climatic Station

- Big Steveson Screen
  - Hair Hygrograph
  - Thermograph
- Small Stevenson Screen
  - Thermometers (Dry, Wet, Max and Min)
- Storage (Ordinary) Rain-gauge [SRG]
- Autographic Rain-gauge [ARG] (Self Recording RG)
- Anemometer (cup type) and Windvane
- Class ‘A’ Pan Evaporimeter
- Sunshine Recorder
- Pyranograph
- Aneroid Barograph and Kevin’s Barometer (inside room)

CONVENTIONAL FCS INSTRUMENTS



FCS siting and fencing

Site Selected Should Conform to WMO/ IMD (BIS) norms

THERMOMETERS

Invented by Galileo in 1857 and measures temperature. Based on the principle of expansion of liquid such as alcohol or mercury. Can also measure daily maximum ad minimums,

Dry bulb: Temperature is indicated by thermometer not affected by moisture of the air.

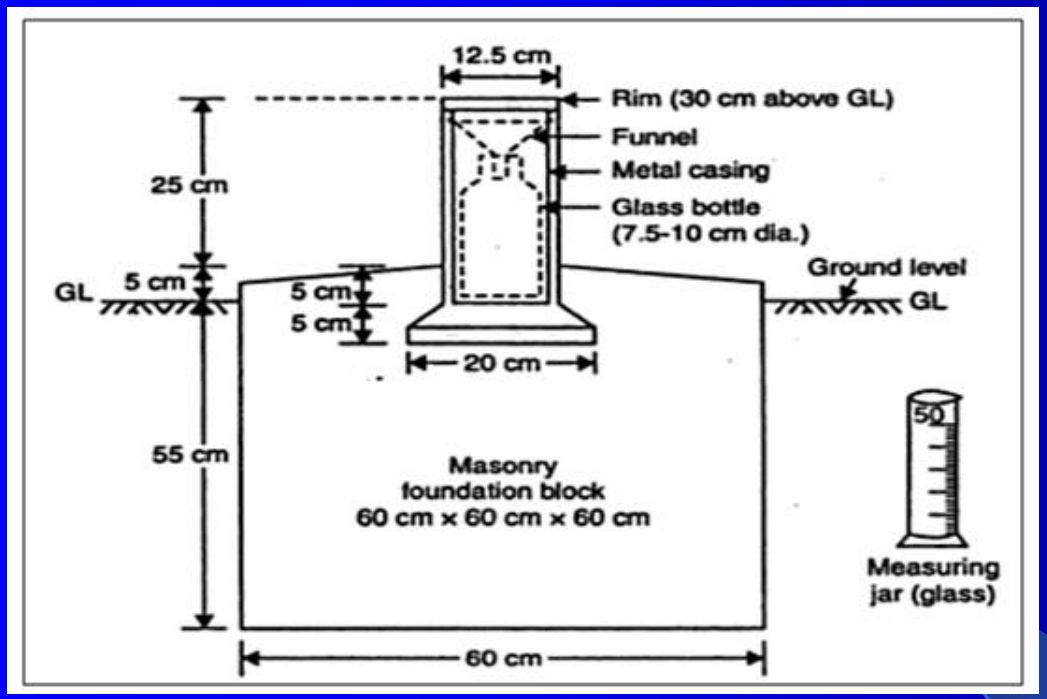
Wet bulb: Adiabatic saturation temperature. Can be measured by using a thermometer with bulb wrapped in wet muslin cloth. The adiabatic evaporation of water from the thermometer bulb and cooling effect is indicated by wet bulb temperature

STEVENSON SCREENS

Stevenson Screen are Made of best Quality Wood, Accurately Assembled with Side Louvers

- Suitable for Housing Thermograph, Hydrograph, Dry, Wet Bulb, Max, Min, Thermometers
- Screen is Designed to Provide Enclosure with Uniform Temperature as that of Out Side Air
- Walls of Screen are Double Louvered and Floor of Staggered Boards Roof is Double Layered with Provision for Ventilation between Layers

STORAGE RAINGAUGES [SRG/ ORG]

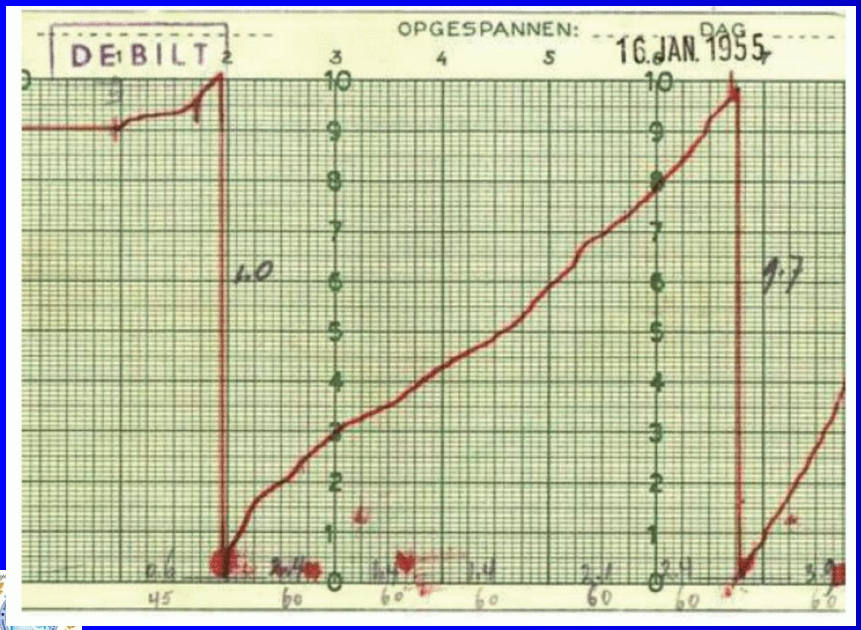


Collector assembled with brass ring
The rainfall falling into the funnel is collected in the receiver and is measured in a special measuring glass graduated in mm of rain fall. When full it can measures 12.5 cm of rain fall

The rainfall is measured every day ar 08: 30 hrs IST. During heavy rains it must be measured 3 to 4 times
The sum total of all the measurement gives total Depth of rainfall of previous 24 hr rainfall

AUTOGRAPHIC/ RECORDING RAINGAUGE [SRRG]

The rainwater collected by the collector is led to the float chamber. The float is having central stud on which pen assembly is fixed. The pen is moving over a daily chart wound over a clock drum. After every 10 mm of rainfall syphoning occurs and recording of rain starts afresh(IS 5225-1969)



WIND SPEED MEASUREMENT

Cup Anemometer

Wind Vane

Wind is Horizontal Movement of Air. Instrument Used to Measure Wind Speed is called an *Anemometer*, which is an Indicator that will Spin due to Wind. Anemometer Rotates at the same Speed as Wind. It gives a Direct Measure of Speed of Wind. Wind Speed is Measured by using Beaufort Wind Scale which is a Scale of 0-12 based on Visual Clues. It is Probably Sufficient that they Recognize Calm Air, and Gentle, Moderate, and Strong Breezes. For example, a Simplified Scale such as Following can be Used

WIND SPEED DESCRIPTION

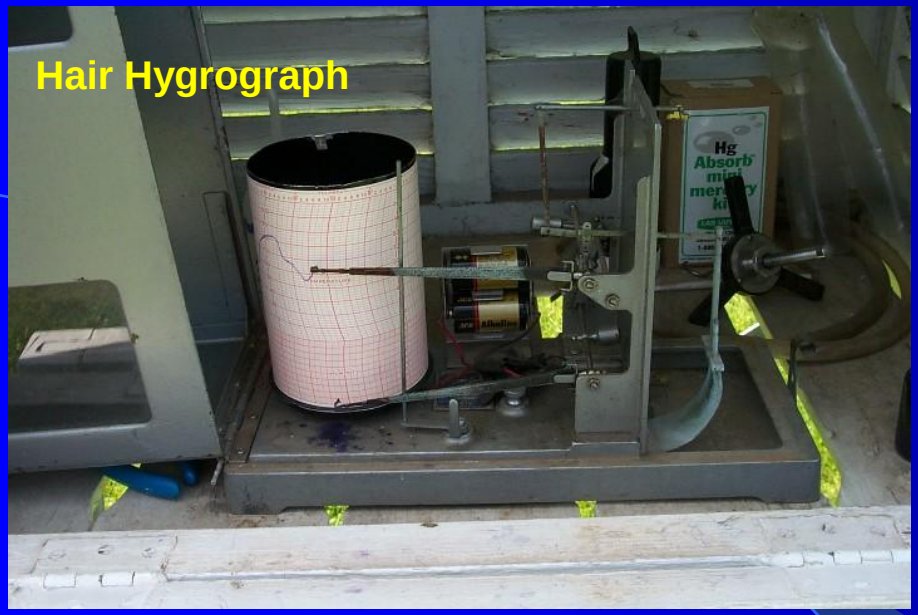
Wind Speed (Km/h)	Term	Description
0-5	Calm	• Smoke Goes Straight Up
6-20	Light	• Wind is Felt on Face; Weather Vanes Turn, Leaves Rustle
21-39	Moderate	• Raises Dust; Flags Flap
40-61	Strong	• Large Branches Move; Umbrellas Turn Inside Out
62 or more	Gale/Whole Gale	

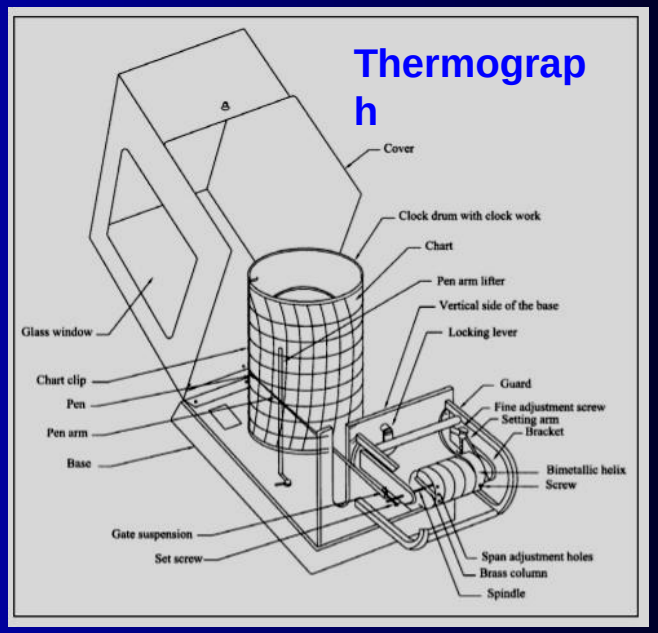
CLASS A EVAPORATION PAN

- Class A Pan Evaporimeter: Uses a still well with a fixed point. Each time a measurement is taken, pan is refilled to the level of the point using a calibrated graduate. The amount of water added is the equivalent of evaporation
- Measure Water Loss of Open Water Bodies to Evaporation Drop in Water Level each Day
- Any Precipitation should be Accounted. Water Temperatures and Wind Speed are Recorded as well.

RECORDING INSTRUMENTS

HYGROGRAPH AND THERMOGRAPH

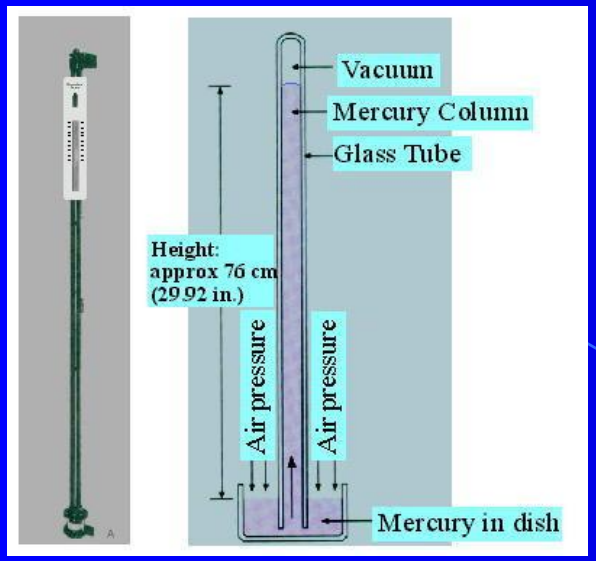




Hygrometer: Hair hygrometer measures relative humidity of the hair. The sensor is bunch of hair. The length of the hair increases as the humidity increases and vice versa. These small changes in length are magnified by means of liver system such that the movement of pen is proportional to the relative humidity. The drum rotates daily mechanical winding of spring or quartz electronic clock.

Thermograph: Consists of a temperature sensitive hilix bimetallic element connected by a system of magnifying linkage which is fixed on a drum driven by mechanical clock. The movement is transmitted to the pen point and recorded on a chart fixed on a revolving clock drum (IS:5910-1970)

BAROMETER



Kevin Barograph

Aneroid Barograph

Mercury Barometer: Atmospheric pressure balances a column of mercury , the height of which can be precisely measured.

Aneroid Barometer: It contains a flexible- walled evacuated capsule, the wall of which deflects with changes in atmospheric pressure. This defection is coupled mechanically to an indicating needle. This is widely used and portable.

PYRANOGRAPH & SUNSHINE RECORDERS

Pyranometer: Measures Solar irradiance on a planar surface and measures the solar radiation flux density (W/m^2) from the hemisphere above within a wavelength range of .3 μm to 3 μm.:

Sunshine recorder: Measures Sunshine intensity over day. The main components are special solid glass with good surface finish and a chart paper is inserted in the groove. The sunray's intensity causes a dark spot due to burning. According to the dark spot width, intensity of Sun is measured using supplied measuring scale,(BIS code IS:7243:1974)

SUMMARY

- Metrological measurements are essential in making assessment and forecast of quantum of water and rate of quantum of water in river and reservoirs, tanks and under ground and soil held waters for flood forecasting and also paling water management strategies and to certain extent in reducing the effects of droughts,
- So basic understanding of Physical processes involved one can make timely and accurate forecasts
- Meteorological measurements go long way in climate change forecast.

THANK YOU

June 2015: A sudden storm devastated the Jammu Kashmir region with severe flooding.

June 13, 2013: A sudden clod burst resulted in floods in Himalayan rivers and devastated the area near Keadrnath and also near Badrinath shrines in Uttarakhand

October 03, 2009 riverine floods in Tungabhadra catchment near Kurnool, Mantralayan townships due to flood releases from TB Dam and severe rainfall in downstream catchments

July 25, 2005 Flash floods in Mumbai city shook the metropolis for nearly 2 days due to the rainfall of 994 mm in the Mithi river catchment